PART FOUR

EROSION CONTROL

CHAPTER 13

EROSION CONTROL REQUIREMENTS

13-1. General. Erosion control can be provided by crushed rock blankets for the more severe cases and by ground cover vegetation where no turbulant flows are predictable. Riprap and grass turf are covered in detail here. Other forms of protection such as rock filled baskets, precast slabs, or flowering folage may also be considered in special cases.

13-2. Design criteria.

a. Scour. Hydraulic structures discharging into open channels will be provided with riprap protection to prevent erosion. Two general types of channel instability can develop downstream from a culvert and storm-drain outlet. The conditions are known as either gully scour or a localized erosion referred to as a scour hole. Distinction between the two conditions of scour and prediction of the type to be anticipated for a given field situation can be made by a comparison of the original or existing slope of the channel or drainage basin downstream of the outlet relative to that required for stability.

b. Gully scour. Gully scour is to be expected when the Froude number of flow in the channel exceeds that required for stability. It begins at a point downstream where the channel is stable and progresses upstream. If sufficient differential in elevation exists between the outlet and the section of stable channel, the outlet structure will be completely undermined. Erosion of this type may be of considerable extent depending upon the location of the stable channel section relative to that of the outlet in both the vertical and downstream directions.

c. Scour hole. A scour hole or localized erosion is to be expected downstream of an outlet even if the downstream channel is stable. The severity of damage to be anticipated depends upon the conditions existing or created at the outlet. In some instances, the extent of the scour hole may be insufficient to produce either instability of the embankment or structural damage to the outlet. However, in many situations flow conditions produce scour of the extent that embankment erosion as well as structural damage of the apron, end wall, and culvert are evident.

13-3. Estimating erosion.

a. Empirical methods. Observations and empirical methods have been developed which provide specific guidance relative to the conditions that produce gully scour or only a localized scour hole as well as those required for stable channels.

b. Empirical equations. Empirical equations were developed for estimating the extent of the anticipated scour hole based on knowledge of the design discharge, the culvert diameter, and the duration and Froude number of the design flow at the culvert outlet. However, the relationship between the Froude number of flow at the culvert outlet and a discharge parameter, $Q/D_o^{5/2}$, can be calculated for any shape of outlet and the discharge parameter is just as representative of flow conditions as is the Froude number. The relations between the two parameters for partial and full pipe flow in square culverts are shown in figure 13-1. Since the discharge parameter is easier to calculate and is suitable for application purposes, equations were determined for estimating the extent of localized scour to be anticipated downstream of culvert and storm-drain outlets.

c. Graphic solutions to empirical equations. The equations for the maximum depth, width, length, and volume of scour and comparisons of predicted and observed values are shown in figures 13-2 through 13-5. Minimum and maximum tailwater depths are defined as those less than 0.5 D_o and equal to or greater than 0.5 D_o respectively. Dimensionless profiles along the center lines of the scour holes to be anticipated with minimum and maximum tailwaters are presented in figures 13-6 and 13-7. Dimensionless cross sections of the scour hole at a distance of 0.4 of the maximum length of scour downstream of the culvert outlet for all tailwater conditions are also shown in figures 13-6 and 13-7.

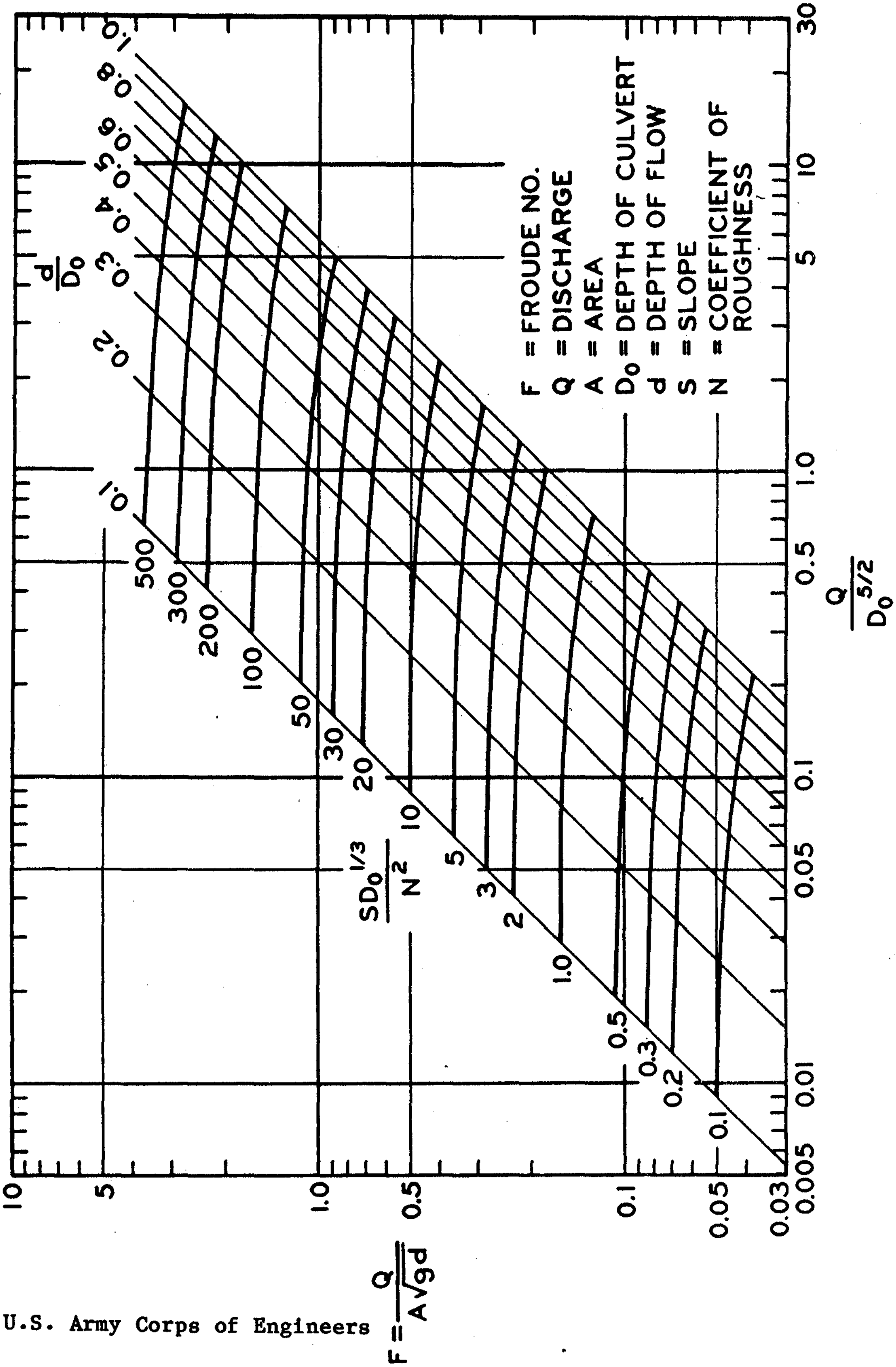

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FIGURE 13-1. SQUARE CULVERT-FROUDE NUMBER

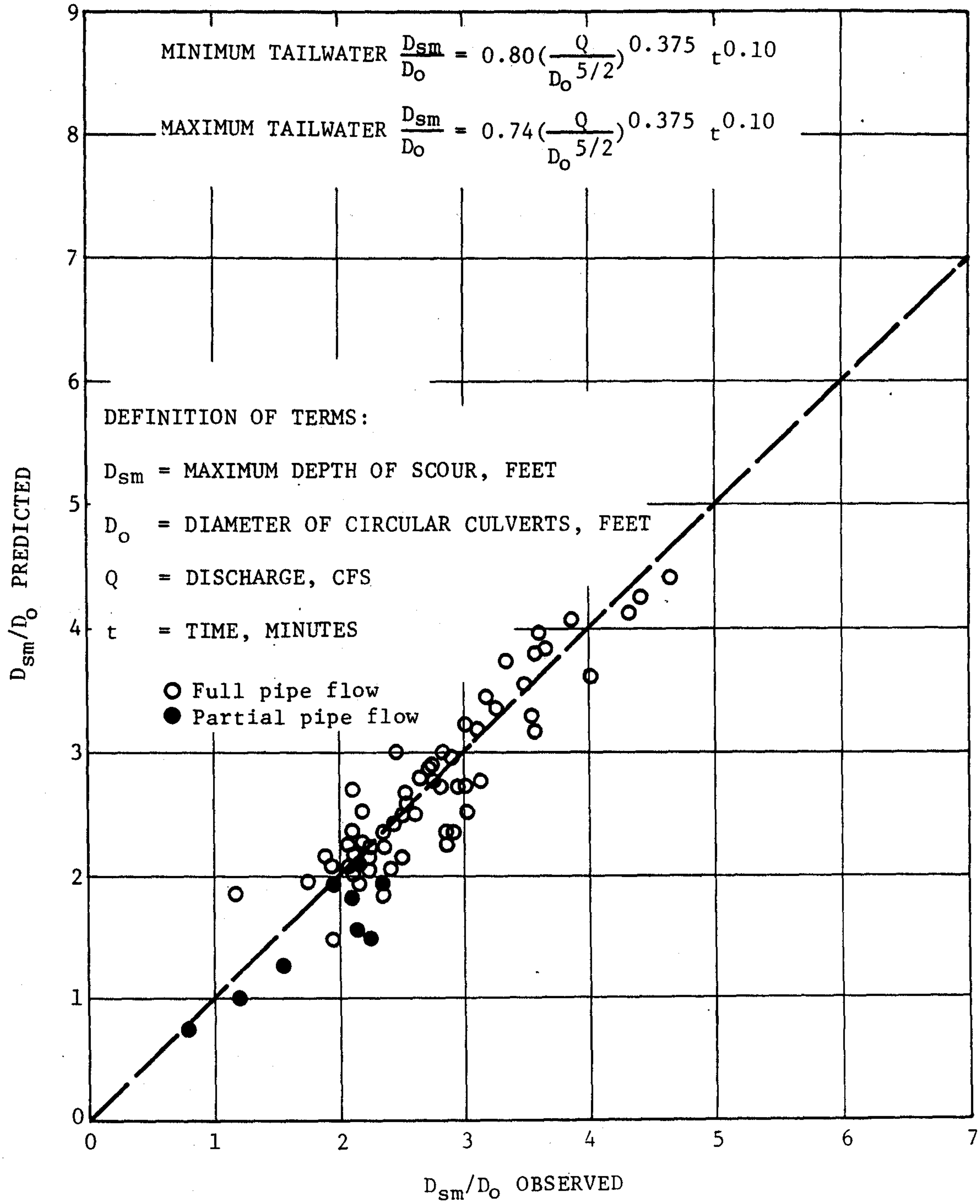

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FIGURE 13-2. PREDICTED SCOUR DEPTH VERSUS OBSERVED SCOUR DEPTH

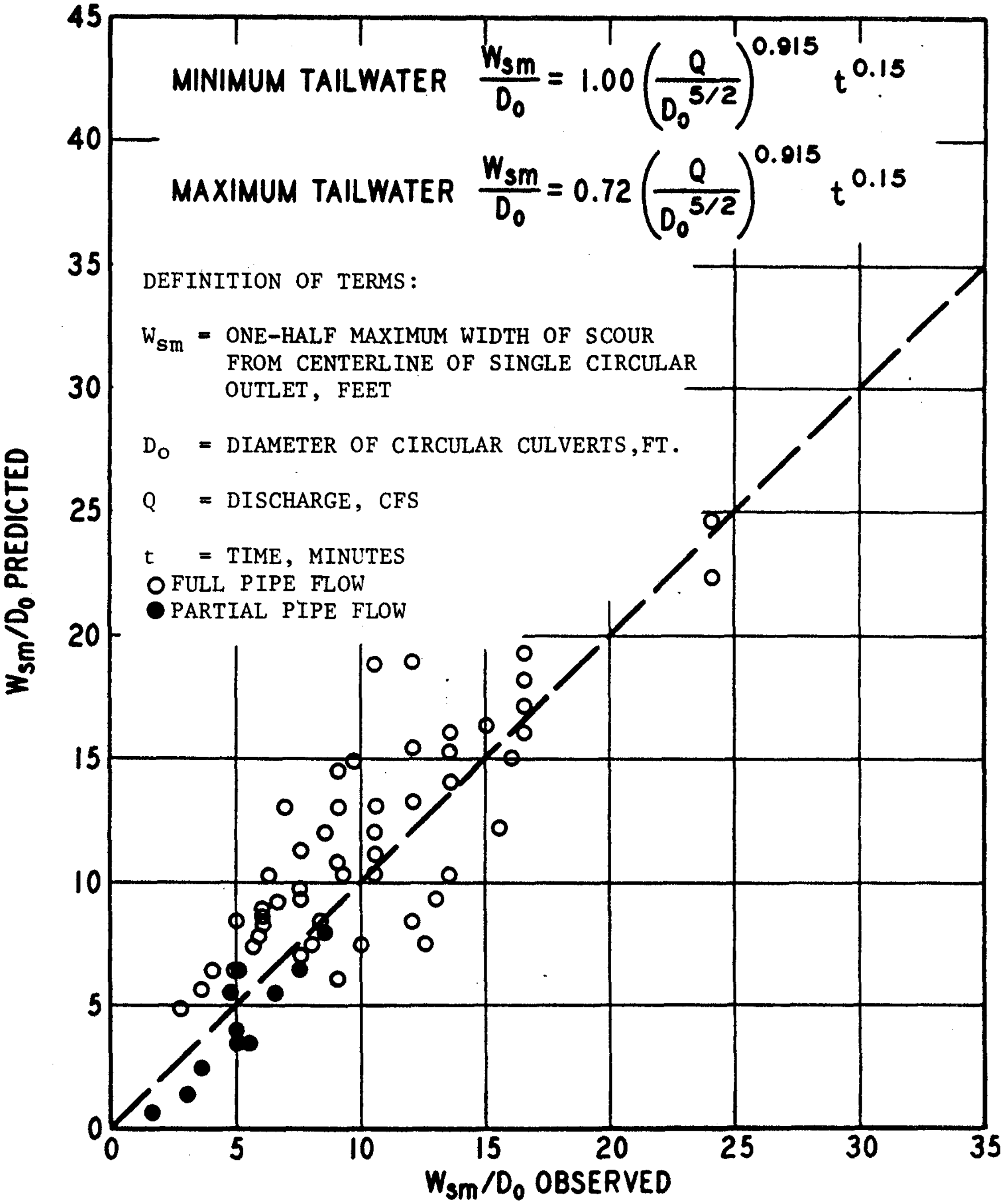

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FIGURE 13-3. PREDICTED SCOUR WIDTH VERSUS OBSERVED SCOUR WIDTH

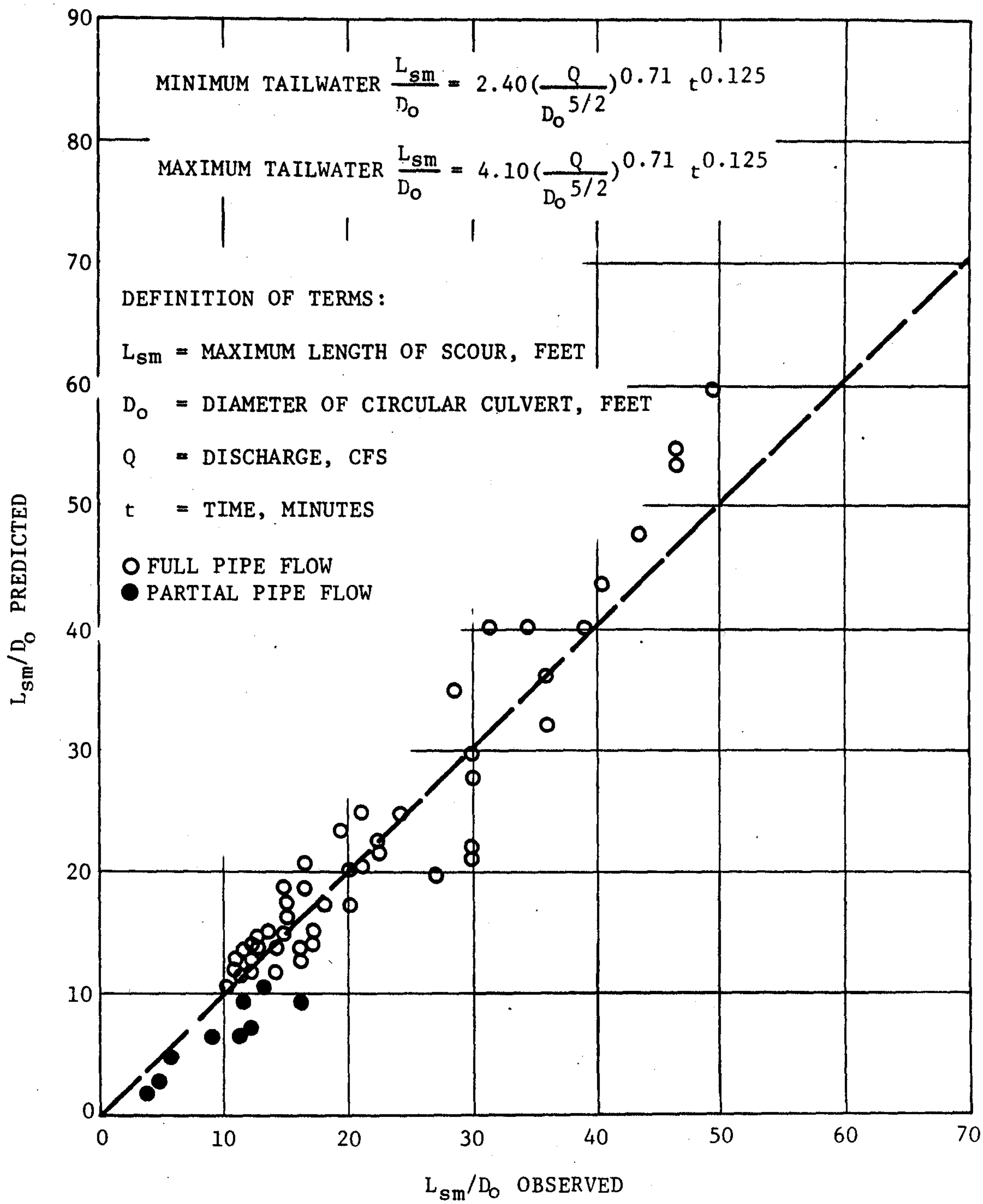

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FIGURE 13-4. PREDICTED SCOUR LENGTH VERSUS OBSERVED SCOUR LENGTH

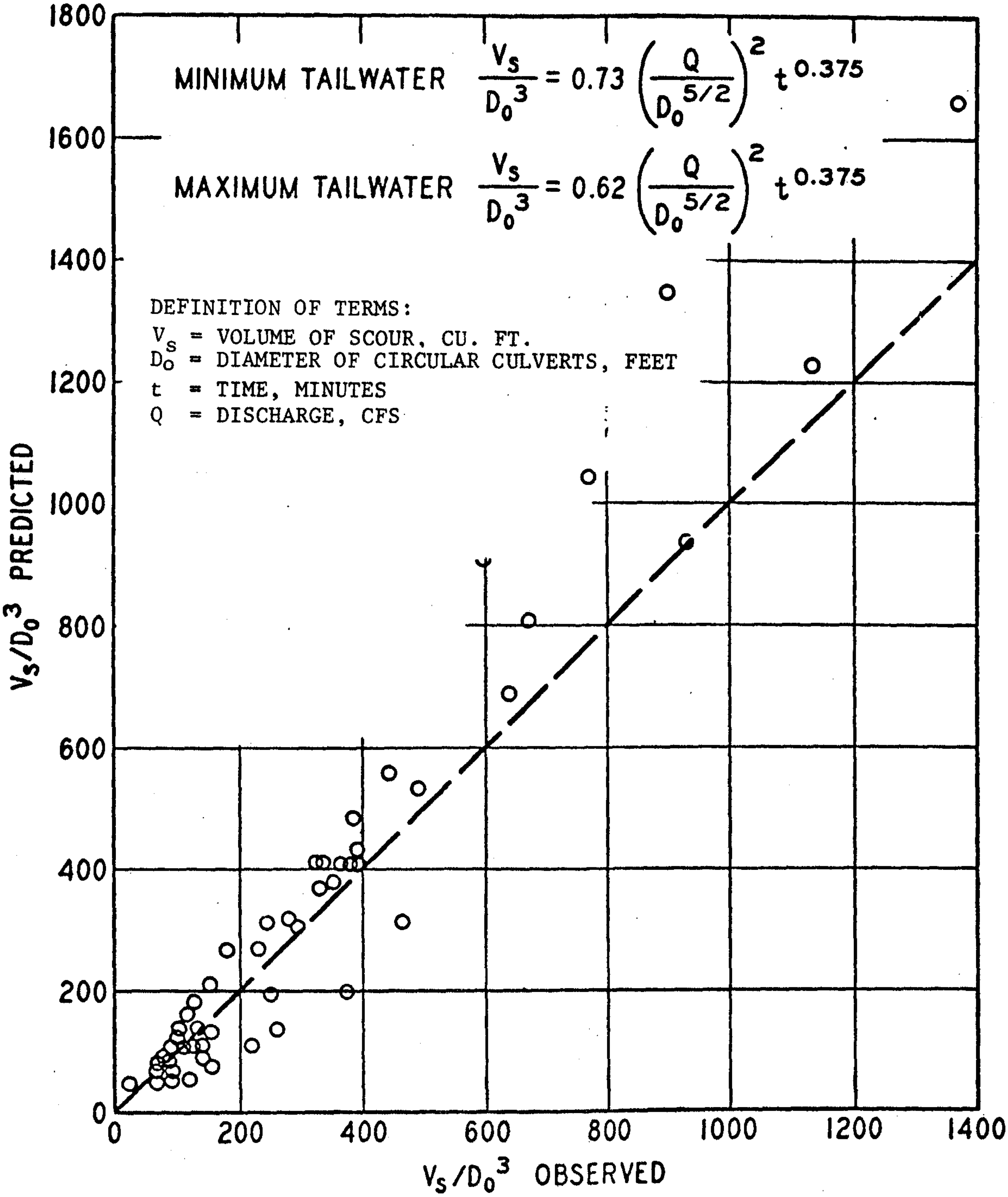

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FIGURE 13-5. PREDICTED SCOUR VOLUME VERSUS OBSERVED SCOUR VOLUME

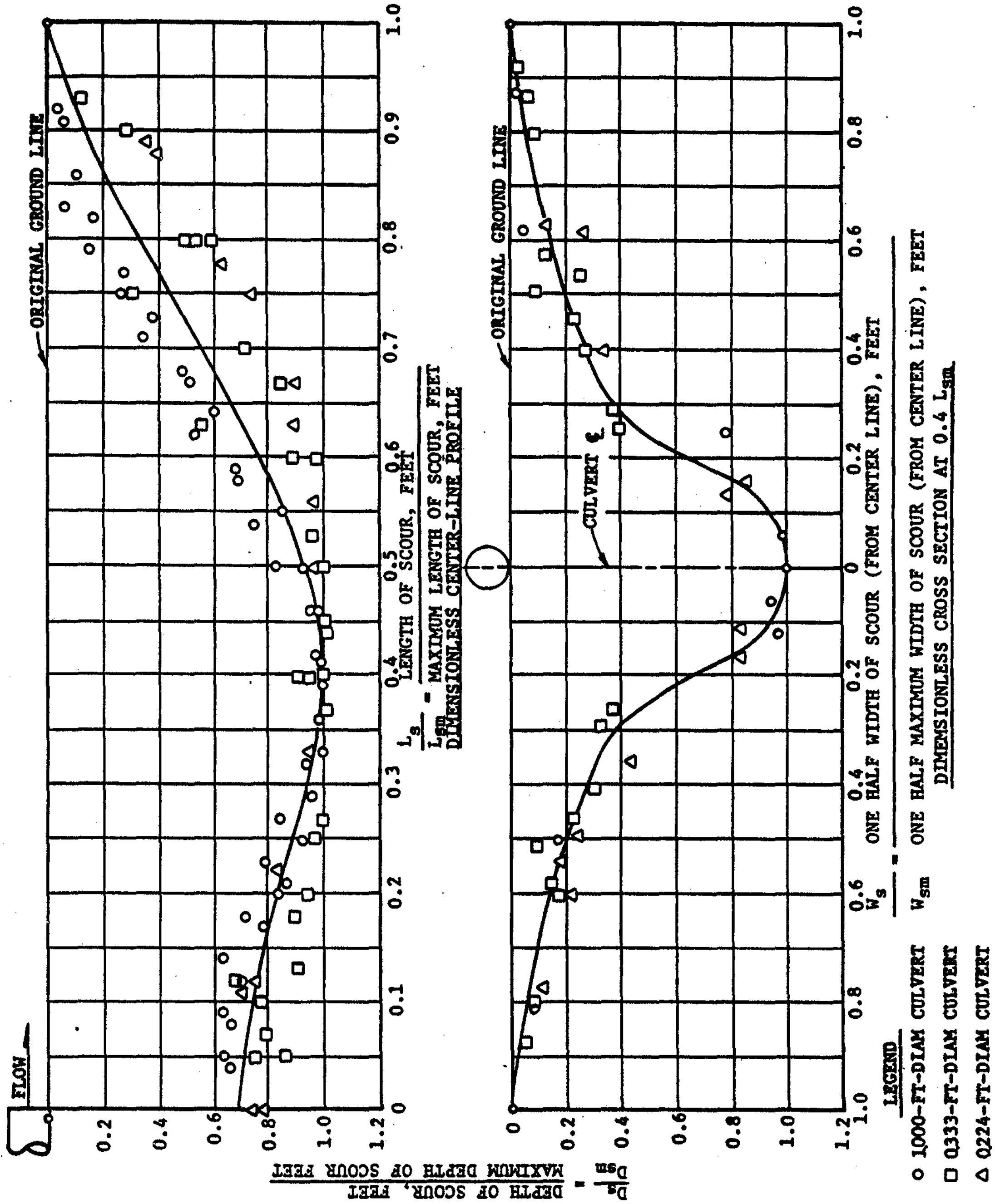

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FIGURE 13-6. DIMENSIONLESS SCOUR HOLE GEOMETRY FOR MINIMUM TAILWATER

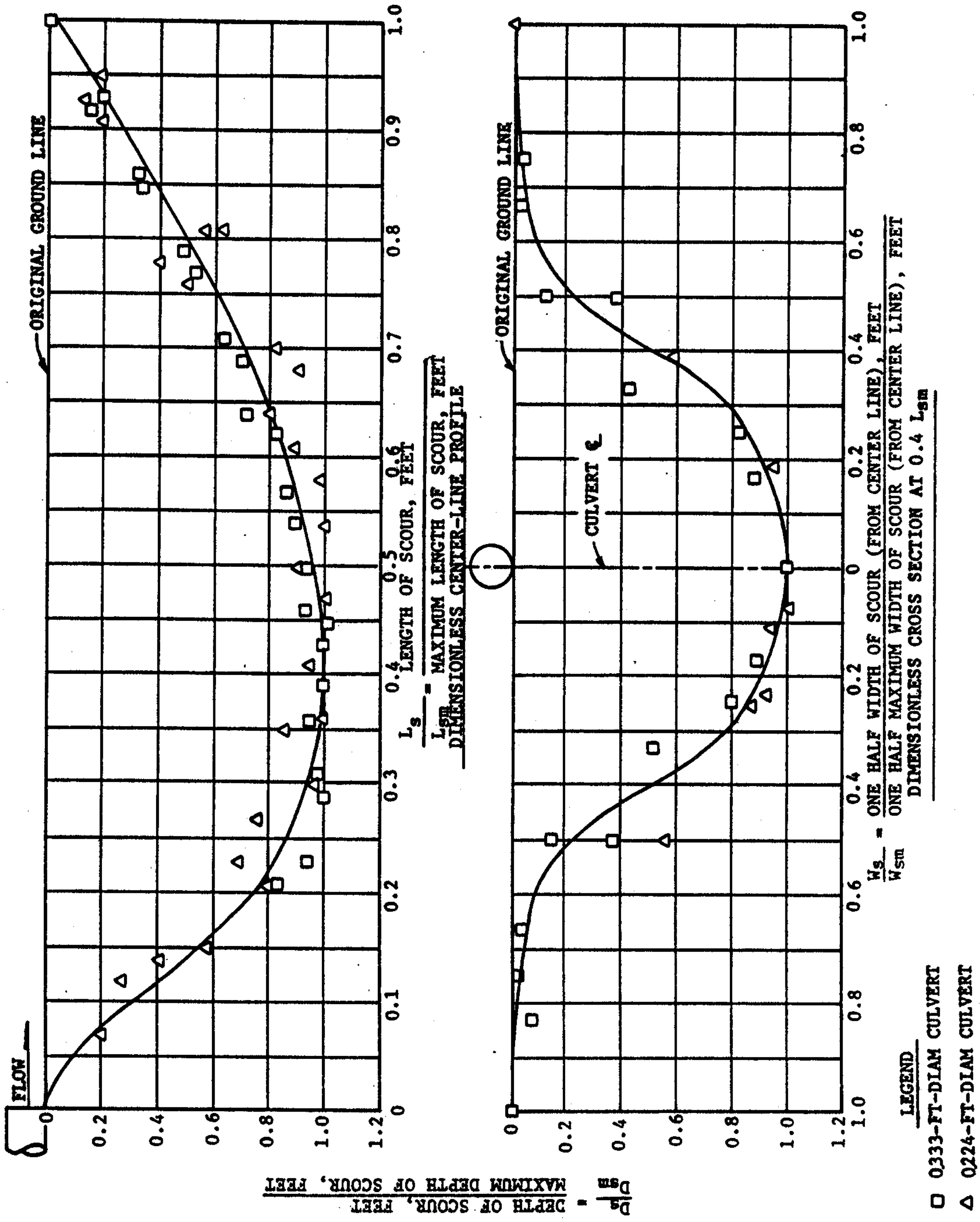

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FIGURE 13-7. DIMENSIONLESS SCOUR HOLE GEOMETRY FOR MAXIMUM TAILWATER